VERIFIED ENGLISH TRANSLATION OF JAPANESE APPLICATION No. 75195/1998

CERTIFICATE OF VERIFICATION

I, Yasuyuki Hata of c/o Saito & Hata International Patent Office, Akasaka-taisei Bldg., 1-18, Akasaka 1-chome, Minato-ku, Tokyo, Japan, hereby certify that I am the translator of the document attached and I state that the attached document is a true and complete translation to the best of my knowledge and belief of Japanese Patent Application No. 75195/1998 filed on March 24, 1998.

Dated this 24th day of November, 2004

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【Document Name】	APPLICATION FOR PATENT
【Serial Number】	74110214
【Filing Date】	March 24, 1998 (Heisei 10)
【Address】	Director General, Patent Office
【International Classification】	H01L 21/205

【Title of the Invention】 Semiconductor Device Manufacturing Apparatus and Semiconductor Device Manufacturing Method

【Number of claims】	16
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【Number of Previous Payment file】	043351
【Amount of Payment】	21000 Yen

【List of Filed Documents】

【Name of Paper】	Specification	1
【Name of Paper】	Drawing	1
【Name of Paper】	Abstract of Disclosure	1

【Number of General Power of Attorney】 9603885

【Necessity for Proof】 yes

【Document Name】 SPECIFICATION

【Title of the Invention】 Semiconductor Device Manufacturing Apparatus and Semiconductor Device Manufacturing Method

【Scope of claim for patent】

1. A semiconductor device manufacturing apparatus that uses a thermal CVD reaction to deposit a film onto a substrate, said apparatus having a power supply means that supplies electric current or electric potential to said substrate or said film deposited thereupon.

2. A semiconductor device manufacturing apparatus which uses a thermal CVD reaction to deposit a film onto a substrate, wherein said apparatus comprising;

a ring provided with electrode terminals that make contact with said substrate or with film that is deposited onto said substrate;

a power supply that applies either a current or a potential to said electrode terminals of said ring: and

a means for moving said ring so as to make said electrode terminals to contact with or to be removed from said substrate or said film that is deposited onto said substrate.

3 A semiconductor device manufacturing apparatus according to claim 2, wherein said ring is provided with positive electrode terminals to which a positive voltage is applied and negative electrode terminals to which a negative voltage is applied, these being disposed in opposition to each other.

4. A semiconductor device manufacturing apparatus according to claim 2, wherein a plurality of said electrode terminals being disposed in opposition on a circle that is concentric to said ring, while said power supply applying a voltage to each one of said electrode terminals, independently, so that a positive

voltage being applied to one and a negative voltage being applied to the other of said opposing electrode terminals, and further wherein said power supply also being possible to sequentially switch the positive and negative voltages that are applied to adjacent electrode terminals.

5. A semiconductor device manufacturing apparatus according to any one of claims 1 to 4, wherein said apparatus is further provided with a means for monitoring the potential of said substrate or said film that is deposited thereupon, and for controlling the current or voltage or the temperature of said substrate, based on that potential.

6. A semiconductor device manufacturing apparatus which enables to set a potential of a substrate or a film that is deposited thereupon, arbitrarily.

7. A semiconductor device manufacturing apparatus according to claim 6, wherein said potential of said substrate or said film deposited thereupon can be set at a ground potential.

8. A semiconductor device manufacturing apparatus which uses a thermal CVD reaction to deposit a film onto a substrate, said apparatus having a means for generating a current or a potential in said substrate or said film that is deposited thereupon, without coming into contact with said substrate or said film.

9. A semiconductor device manufacturing apparatus accoring to claim 8, wherein said means is a magnetic generating means that applies magnetic flux to said substrate or to said film that is deposited thereupon.

10. A method of manufacturing a semiconductor device with using a thermal CVD reaction to deposit a film onto a substrate, wherein said method comprising a step of depositing a film on

said substrate as a current or a potential is applied to said substrate or to said film deposited thereupon.

11. A method of manufacturing a semiconductor device with using a thermal CVD reaction to deposit a film onto a substrate, wherein said method comprising a step of depositing a film on said substrate as a potential of said substrate or said film deposited thereupon is set at an arbitrary value.

12. A method of manufacturing a semiconductor device according to claim 11, wherein said method comprising a step of depositing a film on said substrate as a potential of said substrate or said film deposited thereupon is set at a ground potential.

13. A method of manufacturing a semiconductor device with using a thermal CVD reaction to deposit a film onto a substrate, said method comprising a step of applying a current or a potential to said substrate or said film that is deposited thereupon, without a means for generating said current or said potential coming into contact with said substrate or said film.

14. A method of manufacturing a semiconductor device according to claim 13, wherein magnetic flux are applied to said substrate or said film deposited thereupon.

15. A method of manufacturing a semiconductor device comprising ;

(1) a step of depositing a film onto a substrate using a thermal CVD reaction and

(2) a step of depositing a film by using a thermal CVD reaction as a current or potential is applied to the deposited film.

16. A method of manufacturing a semiconductor device comprising;

(1) a step of forming a trench on a semiconductor substrate,

(2) a step of depositing a barrier layer for the purpose of preventing film diffusion within the trench,

(3) a step of depositing a film onto the barrier layer by using a thermal CVD reaction,

(4) a step of depositing a film by using a thermal CVD reaction while applying a current or a potential to the deposited film, and

(5) a step of polishing the film and the barrier layer, so as to leave the film and barrier layer within the trench so as to form a wire.

【Detailed Description of the Invention】

【Field of the Invention】

The present invention relates to an apparatus for manufacturing and a method for manufacturing a semiconductor device, and more particularly to a semiconductor device manufacturing apparatus and method for the purpose of forming, using a thermal CVD (chemical vapor deposition) method to form on a substrate a metallic film such as a film of copper or aluminum, a high dielectric coefficient layer such as a layer of titanium oxide strontium, and a strong dielectric film such as BST or TZT.

【Prior Arts】

In general, in fabricating a wire (a so-called damascene copper wire) by burying copper in a trench of a wiring pattern, a thermal CVD apparatus is used to deposit copper onto the substrate. Fig. 6 shows a general view of a thermal CVD apparatus in the past.

As shown in Fig. 6, a thermal CVD apparatus in the past has a hollow vacuum chamber 50, a vacuum pump 61 such as a

turbomolecular pump for the purpose of exhausting the inside of the vacuum chamber 50 to a vacuum condition, a substrate holder 52, provided within the vacuum chamber 50, which holds a substrate W, an atomizer 53 which atomizes the copper to be deposited on the substrate W as the raw gas, and a feed port 64 for the purpose of supplying the raw gas from the atomizer 53 to within the vacuum chamber 50.

The substrate holder 52 has a substrate heating mechanism which is capable of controlling the temperature of the substrate W to within the range from 100 ℃ to 400 ℃. When depositing copper, the temperature is controlled to approximately 200℃.

Next, the method of depositing a copper film for the purpose of forming a copper wire using a thermal CVD apparatus of the past will be described. First, a trench is formed in the region in which a wire is to be formed on the silicon oxide film of the semiconductor substrate W.

Next, the above-noted substrate W is supported on top of the substrate holder 52 of the thermal CVD apparatus. The inside of the vacuum chamber 50 is brought to a vacuum condition beforehand by the vacuum pump 51.

Next, the substrate heating mechanism of the substrate holder 52 is caused to operate, so as to heat the substrate to a prescribed temperature. Simultaneously with this action, the Cu(hfac) (tmvs) raw gas, which has been atomized by the atomizer 53 is supplied to the supply port 54, together with a hydrogen carrier gas, and a copper film of a prescribed thickness is deposited onto the substrate W.

Then, using a CMP (chemical mechanical polishing) method, the deposited copper film is polished, so that copper remains only within the trench, thereby forming the copper wire.

In the Japanese Examined Patent Publication(KOKOKU) No. 1-19467 and the Japanese Unexamined Patent Publication (KOKAI)No. 2-119125 and in the Japanese Unexamined Patent Publications (KOKAI) Nos. 3-97871 and 3-257099, there is technology disclosed directed to the application of a voltage to a substrate holder that holds a substrate in a plasma CVD apparatus.

【Problem to be solved by Invention】

The major reaction of the above-described copper deposition reaction is chiefly the disproportionate reaction

$2\ Cu^{+1}$ (hfac) (tmvs) -> Cu^{0} + Cu^{+2} (hfac)2 + 2 (tmvs).

The rate of this reaction is established by the absorption of the 2 Cu^{+1} (hfac) molecules at the deposition surface and the movement of charge and removal of reaction products.

The driving forces of these rate-determining reactions are such things as the thermal energy according to the temperature of the substrate surface, and the amount of raw gas that is supplied, and it is difficult to improve the rate of reaction by means of these quantities.

The above-noted disproportionate reaction is, in principle, a reversible reaction, and it is thought that there is a limit to the control of the direction of the reaction by means of isotropic heat.

In formation of a copper wire using a thermal CVD apparatus of the past, in order to improve coverage it was necessary to lower the substrate temperature, which causes the rate of copper deposition to become slow (for example, 20 nm/minute). As a result, the time for fabrication of the semiconductor device becomes long, this resulting in a drop in productivity.

In the method of the past, because it was not possible to control the crystal orientation in the film that was formed, it was difficult to deposit a film having good quality with polarity alignment.

Additionally, in order to improve the reliability of the copper wires, it is necessary to control the grain growth in the copper film. With the method of the past, however, it was difficult to control grain growth.

In the plasma CVD apparatus technology that was disclosed in the above-noted Japanese Patent Publications, a bias voltage is applied to the substrate, and ions such as argon are allowed to collide with the surface of the substrate, the purpose being to impure the film surface purity and step coverage, and improve the flatness of the film surface, this being intrinsically different from the technology of the present invention, which uses an electrostatic action or the action of an electrical current.

Accordingly, it is an object of the present invention to solve the problems noted above, and to provide an apparatus and method for manufacturing a semiconductor device, whereby it is possible to promote the deposition of a film and to control the rate of film deposition, the crystal orientation, and the growth of grains.

[Means for solving the Problem]

In order to achieve the above-noted object, the present invention has the following described technical constitution.

An apparatus for manufacturing a semiconductor device according to the present invention is a semiconductor device manufacturing apparatus which uses a thermal CVD reaction to deposit a film onto a substrate, and which has a power supply

that either applies a current or a potential to a substrate or to a film that is deposited onto the substrate.

Further, an apparatus for manufacturing a semiconductor device according to the present invention is a semiconductor device manufacturing apparatus which uses a thermal CVD reaction to deposit a film onto a substrate, this apparatus comprising a ring on which the electrode terminals are supported, sa power supply that applies either a current or a potential to the electrode terminals of the ring, and a means for moving the ring so that it makes contact with or is removed from the substrate or with film that is deposited onto the substrate.

The above-noted ring is provided with positive electrode terminals to which a positive voltage is applied and negative electrode terminals to which a negative voltage is applied, each these being disposed in opposition to each other with respect to the ring.

A plurality of the above-noted electrode terminals can be disposed in opposition on a circle that is concentric to the ring, while the power supply applies a voltage to each electrode terminal unit, independently, so that a positive voltage being applied to one and a negative voltage being applied to the other of the opposing electrode terminals, and it also being possible for the power supply to sequentially switch the positive and negative voltages that are applied to adjacent electrode terminals.

A semiconductor device manufacturing apparatus according to the present invention can also have means for monitoring the potential of the substrate or a film that is deposited thereupon, and for controlling the current or voltage or the temperature of the substrate, based on that potential.

A semiconductor device manufacturing apparatus according to the present invention preferably enables the setting of the potential of the substrate or a film that is deposited thereupon to, an arbitrary ground potential or the like.

Another semiconductor device manufacturing apparatus according to the present invention is a semiconductor device manufacturing apparatus that uses a thermal CVD reaction to deposit a film onto a substrate, this apparatus having means for generating a current or a potential in the substrate or a film that is deposited thereupon, without coming into contact with the substrate or a film that is deposited thereupon.

The above-noted generating means is, for example, a magnetic generating means that applies magnetic flux to the substrate or to a film that is deposited thereupon.

A method of manufacturing a semiconductor device according to the present invention is a semiconductor device manufacturing method whereby a thermal CVD reaction is used to deposit a film onto a substrate, whereby the film is deposited as a current or a potential is applied to the substrate or to a film that is deposited thereupon.

A method of manufacturing a semiconductor device according to the present invention is additionally one in which a thermal CVD reaction is used to deposit a film onto a substrate, whereby the film is deposited as the potential of the substrate or a film deposited thereupon is set to an arbitrary ground potential.

Yet another method of manufacturing a semiconductor device according to the present invention is one in which a thermal CVD reaction is used to deposit a film onto a substrate, whereby, for example, magnetic flux are applied so as to apply a

current or a potential to the substrate or a film deposited thereupon, without making contact with the substrate or the film deposited thereupon.

Yet another method of manufacturing a semiconductor device according to the present invention comprises:

(1) a step of depositing a film onto a substrate using a thermal CVD reaction and

(2) a step of depositing a film by using a thermal CVD reaction as a current or potential is applied to the deposited film.

Yet another method of manufacturing a semiconductor device according to the present invention has:

(1) a step of forming a trench on a semiconductor substrate,

(2) a step of depositing a barrier layer for the purpose of preventing film diffusion within the trench,

(3) a step of depositing a film onto the barrier layer by using a thermal CVD reaction,

(4) a step of depositing a film by using a thermal CVD reaction while applying a current or a potential to the deposited film, and

(5) a step of polishing the film and the barrier layer, so as to leave the film and barrier layer within the trench so as to form a wire.

According to the present invention, by applying a current or a potential to a substrate or a film that is deposited thereupon, in addition to a disproportionate reaction, a reduction reaction occurs, the deposition of the film is promoted, and it is possible to control the film deposition rate, the crystal orientation, and the grain growth.

Additionally, because the present invention can be used to set the potential of the substrate or a film that is deposited thereupon to, for example, ground potential, it is possible to obtain a uniform potential distribution generated on the surface thereof because of electrostatic chucking, for example.

【Mode of Operation】

Embodiments of the present invention are described in detail below, with references being made to relevant accompanying drawings.

A first embodiment of the present invention will be explained hereunder with referring to Figs. 1.

Fig. 1 shows simplified view that illustrate the first embodiment of a semiconductor device manufacturing apparatus according to the present invention, with (A) showing the condition in which the electrode terminal of the ring is removed from the surface of the substrate and (B) showing the condition in which the electrode terminal of the ring is in contact with the substrate surface.

As shown in Fig. 1, the thermal CVD apparatus according to the present invention has a hollow vacuum chamber 1, a vacuum pump 2, such as a turbomolecular pump, for the purpose of establishing a vacuum condition inside the vacuum chamber 1, a substrate holder 3 for supporting the substrate W, this being provided within the vacuum chamber 1, a atomizer 4 that atomizes the copper to be deposited onto the substrate into the raw gas, a supply port 5 for the purpose of supplying the raw gas from the atomizer 4 to within the vacuum chamber 1, a ring 7 that has an electrode terminal unit 6 that makes contact with the surface of thes ubstrate W, a piston cylinder apparatus 8 which moves the ring up and down, and a power supply source 9, which is

electrically connected to the electrode terminal unit 6, for the purpose of changing the potential of the surface of the substrate W or supplying a current thereto, via the electrode terminal unit 6.

The substrate holder 3 has a substrate heating mechanism that can control the temperature of the substrate W within the range 100 ℃ and 400℃. When depositing copper, the temperature is controlled to approximately 200℃.

The ring 7 is made of an insulating material, such as alumina.

The end of the rod 8a of the piston cylinder apparatus 8 is mounted to the bottom surface of the ring 7, so that the extension and retraction of the rod 8a causes the ring 7 to rise and descend, the result of this movement being that the electrode terminal unit 6 of the ring 7 makes and breaks its contact with the surface of the substrate W.

The potential and current pattern that is supplied from the power supply source 9 is variable and can be varied so as to control the deposition of the film.

It is also possible to provide a controller 10, which monitors the potential of the surface of the substrate W, via the electrode terminal unit 6 of the ring 7, and which controls the amount of current, the potential, and the temperature of the substrate W.

In the case in which the substrate holder 3 uses an electrostatic chuck to hold the substrate W, an electrical charge is generated on the substrate W by virtue of electrostatic induction thereonto, this resulting in a change in the substrate potential, leading to the possibility of affecting the CVD reaction.

In such cases, it is preferable to use the controller 10 to control the potential of the substrate to the ground potential, for example, thereby achieving a uniform potential distribution.

By doing this, it is possible to improve the uniformity and repeatability of the film.

It is also possible to ground the surface of the substrate W or to set the substrate potential arbitrarily by using the power supply.

The atomizer 4 atomizes Cu (hfac) (tmvs) and hexafluoroacetyl acetonite copper trimethyl vinyl silane to serve as the raw gas for the process.

The atomized raw gas is supplied to the surface of the substrate W via the supply port 5.

Fig. 2 is a cross-section view that shows the process steps for depositing a copper film and forming a copper wire according to the semiconductor device manufacturing method of the present invention.

First, as shown in Fig. 2 (A), a trench 12 is formed in a location in which a wire will be formed on the silicon oxide film 11 of the semiconductor substrate W.

The formation of the trench 12 is done by using reactive ion etching, for example.

The width of the trench 12 can be various, ranging from 0.3 μm to 100μm, and is indicated in this case as being 0.5 μm.

While the depth of the trench 12 will depend on the individual design, this is indicated herein as the example of 0.5 μm.

A barrier layer 13 is formed in the trench 12 to prevent copper diffusion. The material for the barrier layer 13 can be,

for example, Ta, TaN, TiN, WN, or WSiN, and the thickness thereof is approximately 10 nm.

Next, the substrate W, onto which is formed the barrier layer 13, is placed in the vacuum chamber 1 as shown in Fig. 1. The vacuum pump 2 is used to establish a vacuum within the vacuum chamber 1 beforehand.

Next, the substrate heating mechanism of the substrate holder 3 is caused to operate, so as to heat the substrate W to a prescribed temperature (of approximately 180 ℃).

Simultaneously with this, the Cu (hfac) (tmvs), which is the raw gas, is supplied together with hydrogen carrier gas so that, as shown in Fig. 2 (B), a copper film 14 having a film thickness of 100 nm is deposited.

The pressure of the raw gas is approximately 13 Torr.

When doing this, because the rod 8a of the piston cylinder mechanism 8 is extended, the electrode terminal unit 6 of the ring 7 is removed from the surface of the substrate W (refer to Fig. 1 (A)).

The copper deposition reaction when the above is done is chiefly the disproportionate reaction

$$2\ Cu^{+1}\ (hfac)\ (tmvs) \rightarrow Cu^{0} + Cu^{+2}\ (hfac)2 + 2\ (tmvs).$$

The rate of film growth is approximately 100 nm/minute.

Next, the rod 8a of the piston cylinder mechanism 8 is caused to retract, so that the electrode terminal unit 6 of the ring 7 comes into contact with the surface of the copper film 14 that was deposited on the substrate (refer to Fig. 1 (B)).

A potential of -20 V from the power supply source 9, via the electrode terminal unit 6, is applied to the surface of the substrate W. By means of this potential, vapor phase Cu (hfac) is attracted.

Of the Cu (hfac), concentration of electrons and polarization occur because of the differences in electron affinity of constituent electrons thereof.

Molecules are attracted to the surface because of electrostatic attraction. At the surface of the substrate W, electron supply occurs and, in addition to the disproportionate reaction, the reduction reactions

$$2\ Cu^{+1}\ (hfac) + e + H^{*} \rightarrow Cu^{0} + H(hfac)$$

and

$$2\ Cu^{+2}\ (hfac)2 + 2e + H2 \rightarrow Cu^{0} + 2H(hfac)$$

occur, so that the deposition of copper is promoted.

The hydrogen in these reactions is supplied into the vacuum chamber 1 as a carrier for the Cu (hfac) (tmvs).

The rate of deposition under these conditions is 150 nm/minute. The action of the potential causes orientation of the crystal in the direction of the electrical field.

Thus, as shown in Fig. 2 (C), a copper film 15, having a film thickness of 700 nm, is deposited.

Then, as shown in Fig. 2 (D), CMP (chemical mechanical polishing) is used to polish the copper films 14 and 15 and the barrier layer 13, so that the copper films 14 and 15 and the barrier layer 13 remain only within the trench 12, this forming the copper wire 16.

In this embodiment of the present invention, the first step of depositing a copper film with no current supplied is separate from a second step of depositing a copper film while supplying a current. The copper that is deposited in the first step serves as a seed layer for the purpose of supplying a uniform potential distribution.

It is also possible to cause the electrode terminal 6 of the ring 7 to come into contact with the barrier layer 13 from the beginning for deposit of a copper film, in which case, because the potential distribution within the substrate surface is determined by the resistance of the barrier layer 13, to achieve a uniform potential distribution, it is necessary to use a barrier layer 13 with a low resistance (such as a pure metal like Ta or Nb).

Additionally, the potential that is supplied from the power supply source 9 need not be constant and can, for example, be an alternating current which changes direction at a fixed frequency. In the case of applying an alternating current, the Cu (hfac) molecules in the vapor phase that have a polarity are attracted or repelled, or are caused to rotate by an electrical force.

By selecting an appropriate AC frequency, it is possible to control the orientation and the deposition rate.

Fig. 3 is plan views that illustrate in simplified form the second embodiment of a semiconductor manufacturing apparatus according to the present invention.

As shown in Fig. 3, in the second embodiment the electrode terminal that is mounted to the ring 7 is made up of four positive electrode terminals 20 ⋯ ⋯ and four negative electrode terminals 21 ⋯ ⋯ , these electrode terminals being disposed in opposing manner with a prescribed interval therebetween.

The positive electrode terminals 20 and the negative electrode terminals 21 can be supplied current from the power supply source 9.

In the second embodiment of the present invention, as shown in Fig. 2 (B), a copper film 14 is deposited to a depth of 100 nm on a barrier layer 13, after which the positive electrode terminals 20 and the negative electrode terminals 21 are brought into contact with the surface of the substrate W and a current is caused to flow in the surface of the substrate W.

In this condition, Cu (hfac) (tmvs) is supplied along with hydrogen, and CVD is performed at a substrate temperature of 180 ℃.

In general, there is a tendency for surface atoms and molecules which are attracted to the surface to be, in comparison with atoms in the bulk material, easier to cause to migrate.

This is because of what could be called a quasi-stable condition of the deposition onto the surface and because, in contrast to the bulk material, the bonds at the surface are not as complete.

Therefore, copper atoms and Cu (hfac) that has been deposited onto the surface exhibit electromigration because of the action of the current that flows in the substrate W.

In convention thermal deposition, thermal oscillation causes virtually random migration.

In the case in which a current is flowing in a fixed direction, however, the electrostatic action and the quantum dynamic action known as electron wind force aid the migration, enabling deposition with a given order, in accordance with the direction of current flow.

In accordance with this principle, it is possible to utilize the direction of current flow to control the orientation of the growth of the film.

The potential that is supplied from the power supply source 9 need not be constant and can, for example, be an alternating current which changes direction at a fixed frequency.

The arrangement of the positive electrode terminals 20 and the negative electrode terminals 21 is arbitrary, and can also be established so that the positive electrode terminals 20 and the negative electrode terminals 21 alternate.

The number of positive electrode terminals 20 and the negative electrode terminals 21 is also arbitrary.

Additionally, it is possible to provide a controller 10 such as described with regard to the first embodiment.

Fig. 4 is a plan view that shows in simplified form the third embodiment of a semiconductor device manufacturing method according to the present invention.

As shown in Fig. 4, in the third embodiment there are eight electrode terminals 30 arranged concentrically about the ring 7 at a uniform interval.

Each of the electrode terminals 30 is connected independently to the power supply terminals a through h of the power supply source 9, and has a voltage applied to it independently.

For example, if a positive voltage is applied in the sequence a → b → c → d, and simultaneously a negative voltage is applied in the sequence e → f → g → h, the direction of current flow between the electrode terminals 30 will rotate with a fixed period.

By doing this, an averaged current will flow within the surface of the substrate, so that surface atoms and attracted molecules are encouraged to migrate by the current, which is parallel to the substrate surface, this resulting in an imparted

directionality, so that a controlled film is deposited by the action of the current.

More specifically, the migration encourages the diffusion of atoms at the crystal grain boundaries and encourages grain growth, this having effects such as achieving large crystal grains. With large crystal grains, because the grain boundaries are small, immunity to electromigration when wiring is formed results in the formation of highly reliable wires.

Additionally, a film resulting from grain growth having directionality that is imparted by a current that is parallel to the substrate surface is in a stable energy state under this current stress.

Current flowing after the formation of the wires also flows in parallel to the substrate surface, in the same plane as current stress during the growth of the film.

As described above, the film is deposited in a manner so that it is in the most energy stable condition under current stress, and is in an energy stable condition even when current is flowing in the wiring. Because of this, it is possible to achieve a film that is immune to current stress.

The potential that is supplied from the power supply source 9 need not be constant and can, for example, be an alternating current which changes direction at a fixed frequency.

The number and arrangement of the electrode terminals 30 are also arbitrary and, as noted for the first embodiment, it is possible to provide a current controller 10.

Fig. 5 (A) and (B) are drawings that illustrate in simplified form the fourth embodiment of a semiconductor device manufacturing method according to the present invention.

Whereas in the first through third embodiments of the present invention an electrode terminal makes contact with the substrate W or with a film that is deposited thereupon, this being the means for applying either current or a potential, in the fourth embodiment a current or a potential is apply by a method that does not require contact with the substrate W or with a film that is deposited thereupon.

Specifically, for example, as shown in Fig. 5 (A), a coil 40 is provided that is wound in a direction that is parallel to the substrate holder 3, a current being caused to flow in the coil 40 by a power supply 51, thereby applying magnetic flux 42 in a direction that is perpendicular to the substrate W.

By doing this, an eddy current is developed within the surface of the substrate W, thereby encouraging the deposition of the film.

By controlling the magnetic flux to be applied, it is possible to control the rate of film deposition, the crystal orientation, and grain growth.

As shown in Fig. 5 (B), by providing a coil 43 that is wound in a direction that is perpendicular to the substrate holder 3, a current being caused to flow in the coil 43 by the power supply 51, thereby applying magnetic flux 44 in a direction that is perpendicular to the substrate W.

According to the fourth embodiment of the present invention, because there is no need for a mechanism to move a ring having electrode terminals, the hardware is simplified and made smaller.

Also, because there is no need to consider such things as the contact condition between the electrode terminals and the

substrate W, it is possible to achieve reliable application of either a current or a potential.

The present invention is not restricted to the above-described embodiments, and can be the subject of variations which fall within the technical scope as set forth in the claims for the present invention.

The present invention can be applied not only to a copper film, but also to deposition of metal films such as Al, Au, Ag, Ti, and Ni, and of insulation films such as Parylene having polarity.

The present invention can also be applied to the formation of films that have a polarity, such as strong dielectric films of strontium titanate, titanium oxide barium, BST, lead titanate, and the like, in which case the deposited film is oriented in the direction of the electrical field, resulting in deposition of a film with uniform polarity.

According to the present invention, by applying a current or a potential to a substrate or to a film that is deposited onto the substrate, in addition to a disproportionate reaction, a reduction reaction occurs, thereby encouraging the deposition of the film.

As a result, the time required for manufacture of the semiconductor device is shortened, and the productivity is improved.

Because the present invention enables control of the crystal orientation in the deposited film, it enables deposition of a film with high quality and uniform polarity.

Because the present invention enables control of the film grain growth, it improves the reliability of wires.

Additionally, because the present invention enable the potential of the substrate or the film deposited thereupon to be set to the ground potential, it enables the achievement of a uniform potential distribution over the surface of the substrate, which can normally be disturbed by, for example, electrostatic chucking, thereby improving the uniformity and repeatability of the deposited film.

【BRIEF DESCRIPTION OF THE DRAWINGS】

Fig. 1 is a drawing that illustrates in simplified form a semiconductor device manufacturing apparatus according to the first embodiment of the present invention, with (A) showing the condition in which the electrode terminal of the ring is removed from the surface of the substrate and (B) showing the condition in which the electrode terminal of the ring is in contact with the substrate surface.

Fig. 2 is a cross-sectional view of the process steps for the purpose of depositing a copper film and forming a copper wire, according to the semiconductor device manufacturing method of the present invention.

Fig. 3 is a plan view that shows in simplified form a semiconductor device manufacturing apparatus according to the second embodiment of the present invention.

Fig. 4 is a plan view that shows in simplified form a semiconductor device manufacturing apparatus according to the third embodiment of the present invention.

Fig. 5 (A) and (B) are drawings that show in simplified form a semiconductor device manufacturing apparatus according to the fourth embodiment of the present invention.

Fig. 6 shows one of typical conventional thermal CVD apparatus.

【Explanation of Symbols used in this specification】

1 vacuum chamber

2 vacuum pump

3 substrate holder

4 atomizer

5 supply port

6 electrode terminal

7 ring

8 piston cylinder apparatus

9 power supply source

10 controller

11 silicon oxide film

12 rench

13 barrier layer

14 copper film

15 copper film

16 copper wire

20 positive electrode terminal

21 negative electrode terminal

30 electrode terminal

a ～ h electrode terminal

W substrate

[Name of Document] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Object of the Invention] It is an object of the present invention to provide an apparatus and method for manufacturing a semiconductor device, whereby it is possible to control the rate of film deposition, the crystal orientation, and the growth of grains.

[Means for solving the Problem] A semiconductor device manufacturing apparatus which uses a thermal CVD reaction to deposit a film onto a substrate, wherein said apparatus comprising a ring 7 provided with electrode terminals 6 that make contact with said substrate W or with film that is deposited onto said substrate; a power supply 9 that applies either a current or a potential to said electrode terminals 6 of said ring 7: and a piston cylinder means 8 for moving said ring 7 so as to make said electrode terminals 6 to contact with or to be removed from said substrate or said film that is deposited onto said substrate.

[Selected Figure] Fig. 1

Fig. 1

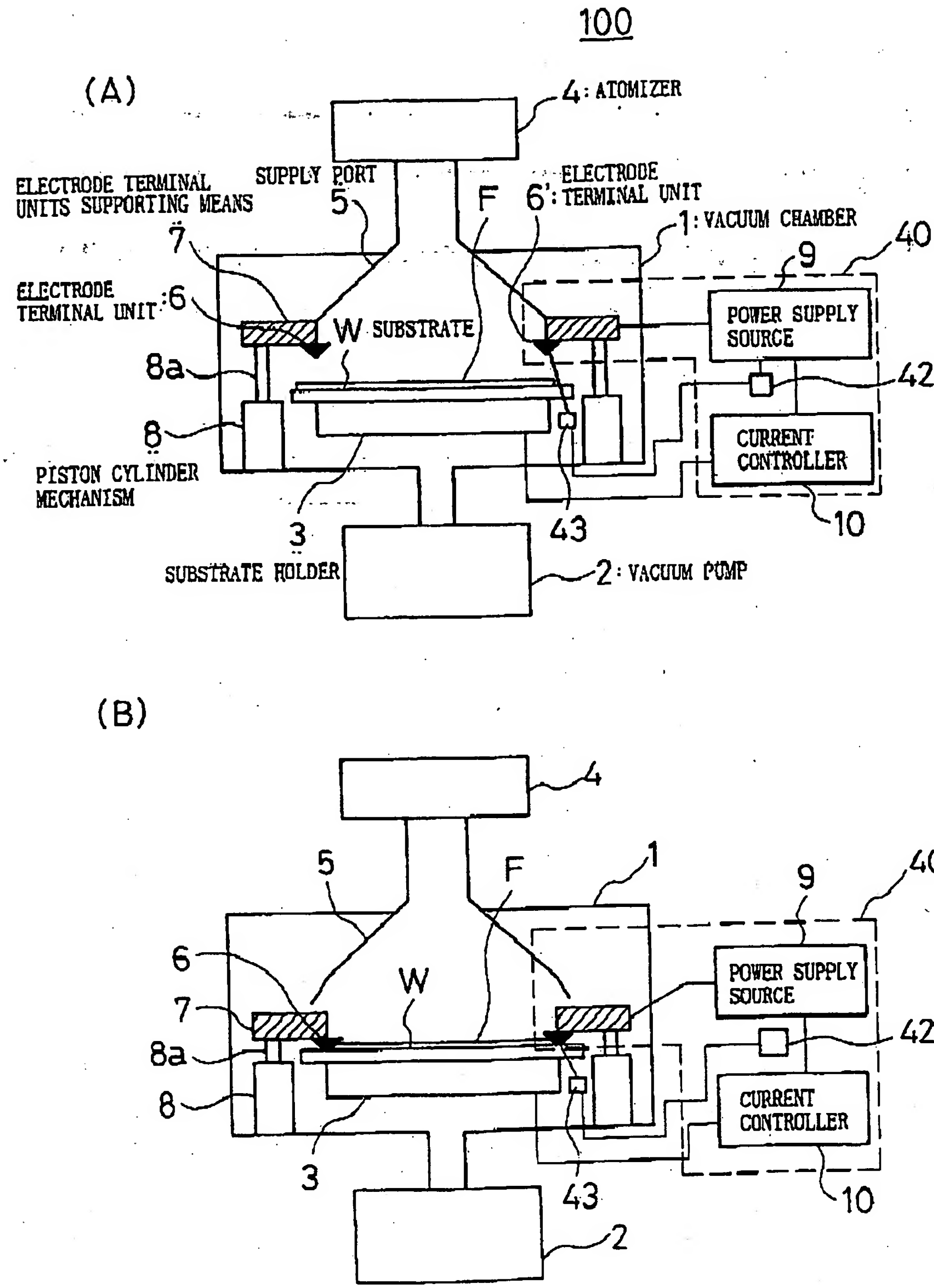
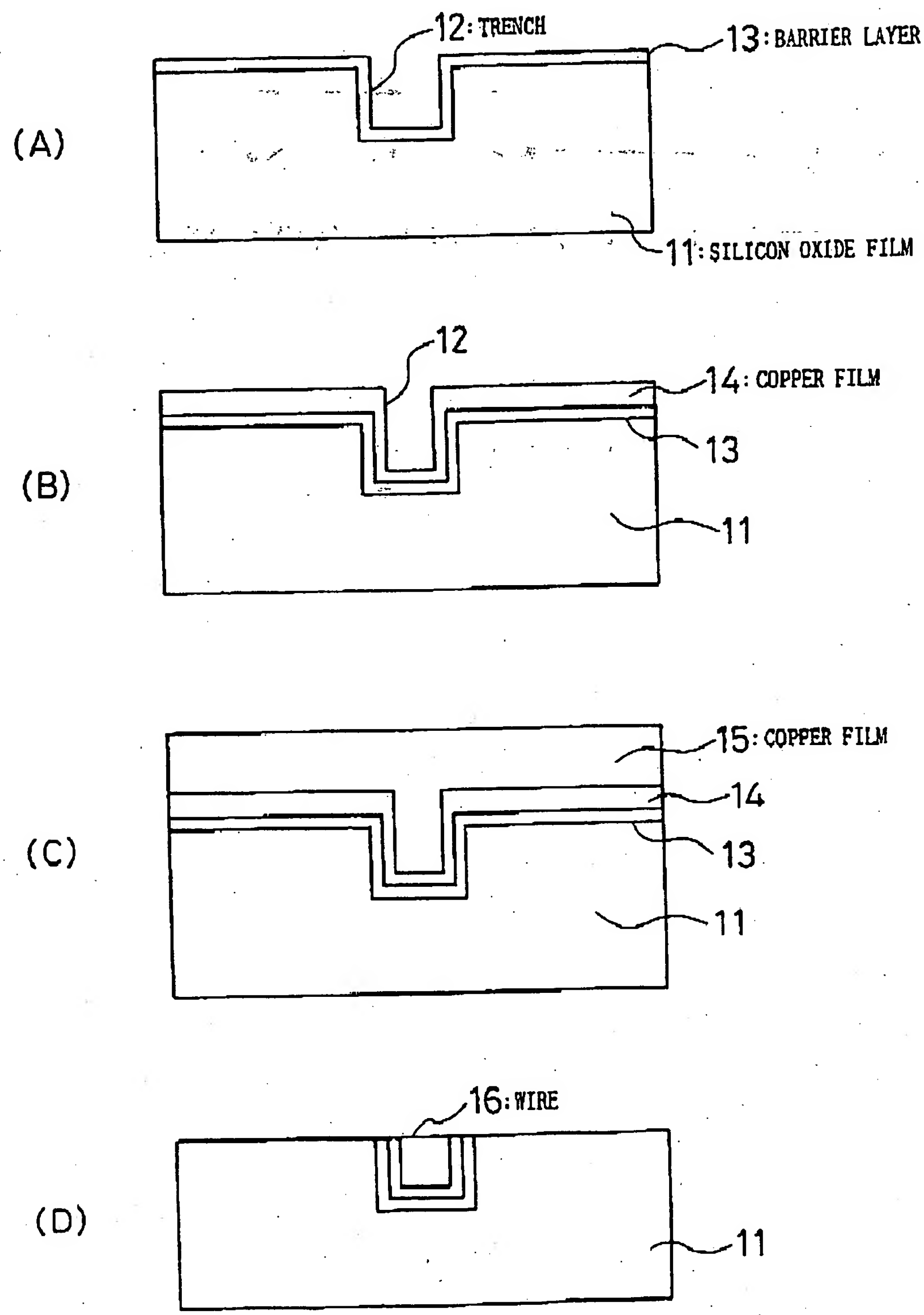
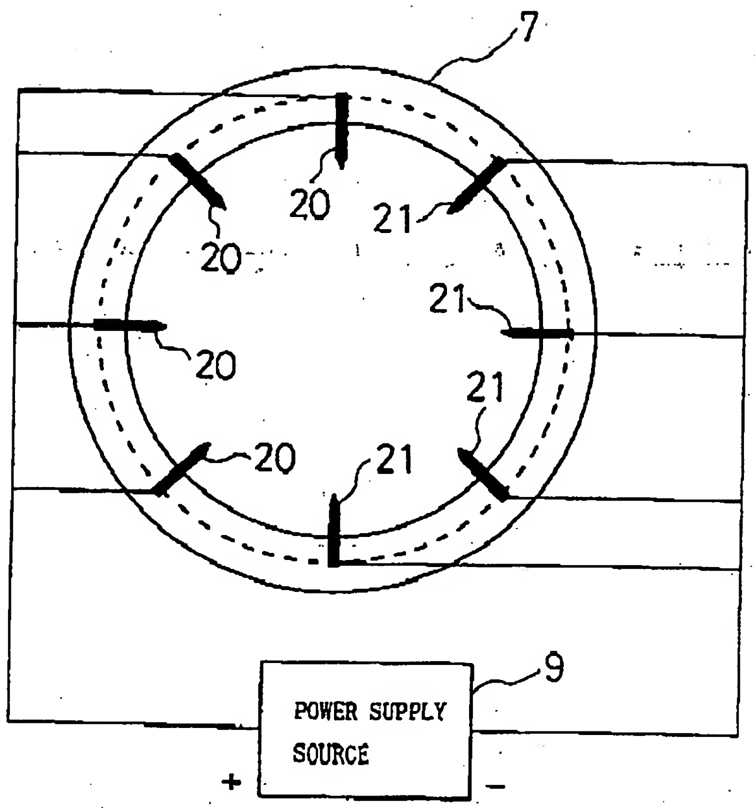

100
(A)
4: ATOMIZER
SUPPLY PORT
5
ELECTRODE TERMINAL UNITS SUPPORTING MEANS
7
F
6': ELECTRODE TERMINAL UNIT
1: VACUUM CHAMBER
40
9
ELECTRODE TERMINAL UNIT: 6
W SUBSTRATE
POWER SUPPLY SOURCE
8a
42
8
CURRENT CONTROLLER
PISTON CYLINDER MECHANISM
3
43
10
SUBSTRATE HOLDER
2: VACUUM PUMP
(B)
4
5
F
1
9
40
6
W
POWER SUPPLY SOURCE
7
42
8a
8
CURRENT CONTROLLER
3
43
10
2

Fig. 2


(A)
12: TRENCH
13: BARRIER LAYER
11: SILICON OXIDE FILM
(B)
12
14: COPPER FILM
13
11
(C)
15: COPPER FILM
14
13
11
(D)
16: WIRE
11

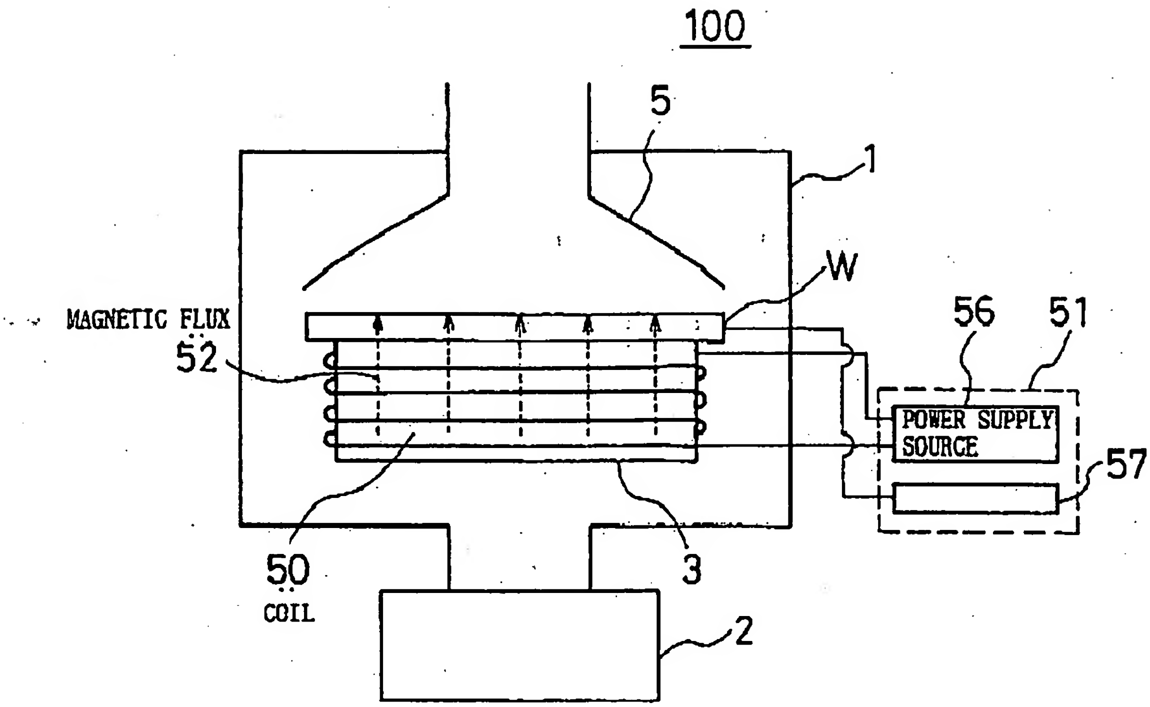
3/6

Fig. 3

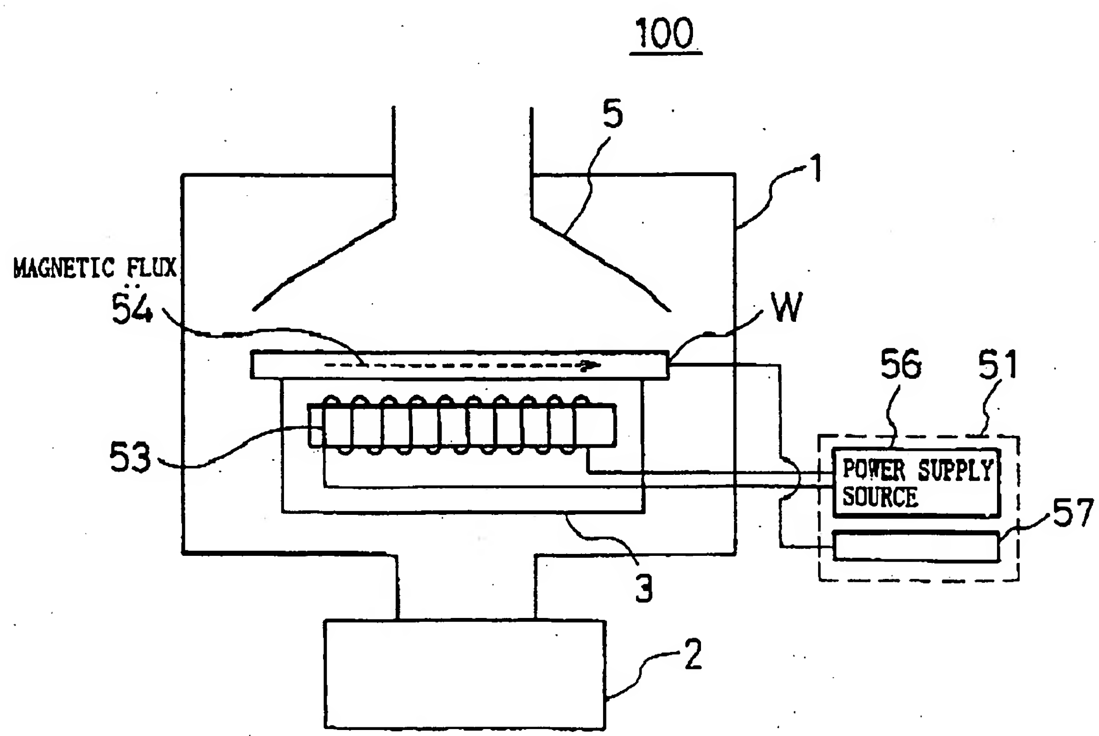


2 0 : POSITIVE ELECTRODE TERMINAL
2 1 : NEGATIVE ELECTRODE TERMINAL

Fig. 5


100
5
1
W
MAGNETIC FLUX
52
56
51
POWER SUPPLY SOURCE
57
50
COIL
3
2

(A)


100
5
1
MAGNETIC FLUX
54
W
56
51
53
POWER SUPPLY SOURCE
57
3
2

(B)

Fig. 6